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ON WAVE NATURE OF MATTER*

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Plates II A and B

ABSTRACT. The molecular beams obtained by vaporising sulphur and paraffin have been allowed to pass through a slit and condense on an ice-cooled glass plate. It is observed that the deposited pattern consists of parallel lines with their lengths parallel to the length of the slit. A tentative explanation is offered that the fringe system is produced by diffraction of a type of waves associated with the molecules at the slit. On this assumption the corresponding wavelengths have been calculated and have been found to be of the order of .027 mm in both the cases. Such a wavelength is different from De Broglie waves and is of the order of those corresponding to vibrations of the single molecules.

INTRODUCTION

In 1947, while working under the guidance of Professor Massey of London University, the author observed that vapours of paraffin and sulphur, after passing through a circular aperture, deposit in the form of concentric rings on an ice-cooled plate but could not ascertain the phenomenon to be the diffraction of a type of radiation associated with the molecular beam. On reaching India, the author pursued the investigation to study the actual nature of the phenomenon.

PRINCIPLE OF THE EXPERIMENT

The actual experimental arrangement is illustrated in Fig. 1 and the parts are given below :

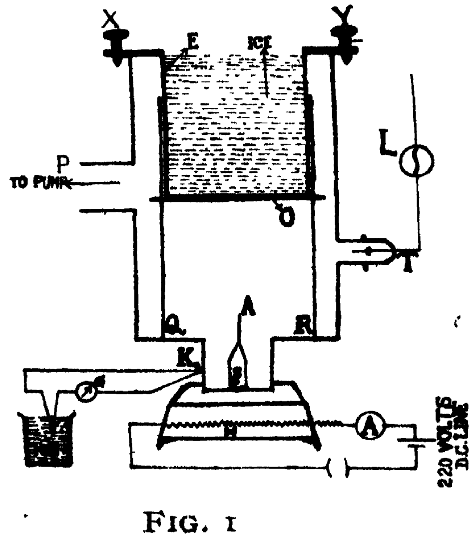

FIG. 1

* Communicated by Prof. S. N. Bose.

K—Calibrated thermo-junction for recording temperature.

H—An electric heater.

L—An induction coil for passing a discharge through a tungsten electrode, I.

P—Pump. The pumping system consisted of an Apiezon oil pump backed by an oil diffusion pump. Pressure was judged from the no-discharge state and blue luminescences on the glass walls.

A thin film S of the substance was slowly evaporated at pressures of 10^{-4} cms. of mercury and at temperatures near the melting point of the substance ; and the vapours, after passing through the slit A, were deposited on the collecting plate O. The fringe-width was measured with a comparator and the wavelength of the corresponding radiation was measured by assuming that the fringe system is produced by diffraction at the slit. The radiations gave a system of overlapping fringes, as indicated in Fig. 4 of Plate II B, from which the different fringe systems were sorted out and the wavelength was calculated from the equation $\lambda = aW/d$, where a = slit width, W = fringe width and d = distance between the collecting plate and the slit. Only three of the patterns are reproduced in figures 2, 3 and 4, of Plates II A, B.

RESULTS

The results are given in Table I for sulphur and paraffin vapours at two different temperatures.

DISCUSSION

In Table I, column 5, we calculate the average wavelength to be associated with a molecule to produce the kinetic energy given by the kinetic theory of gases with the help of the formula $\frac{1}{2}mv^2 = h\nu$, where $v^2 = 3RT/M$. This gives us the average wavelength $\lambda_{av} = 2hcN/3RT$. From the table it appears that the calculated wavelength is in the range of the observed wavelengths.

From columns 4 and 6, it can be seen that in the case of paraffin three distinct fringe systems give us three different wavelengths, wave numbers corresponding to which are 33.8, 166.3 and 1240.1 cm^{-1} respectively at 74°C, which increase to 57, 248 and 2756 cm^{-1} at 110°C. Similarly in the case of sulphur there are four different wavenumbers ranging from 71 upto 2481 cm^{-1}. Of these only the first two increase at 120°C, the other two remain unaffected by the rise of temperature. These wavenumbers thus correspond to the vapours of the single molecule in the case of paraffin, the smallest wave number, however, is much too small to be accounted for in this way. In the case of sulphur, the frequencies 71 and 213 cm^{-1} are in

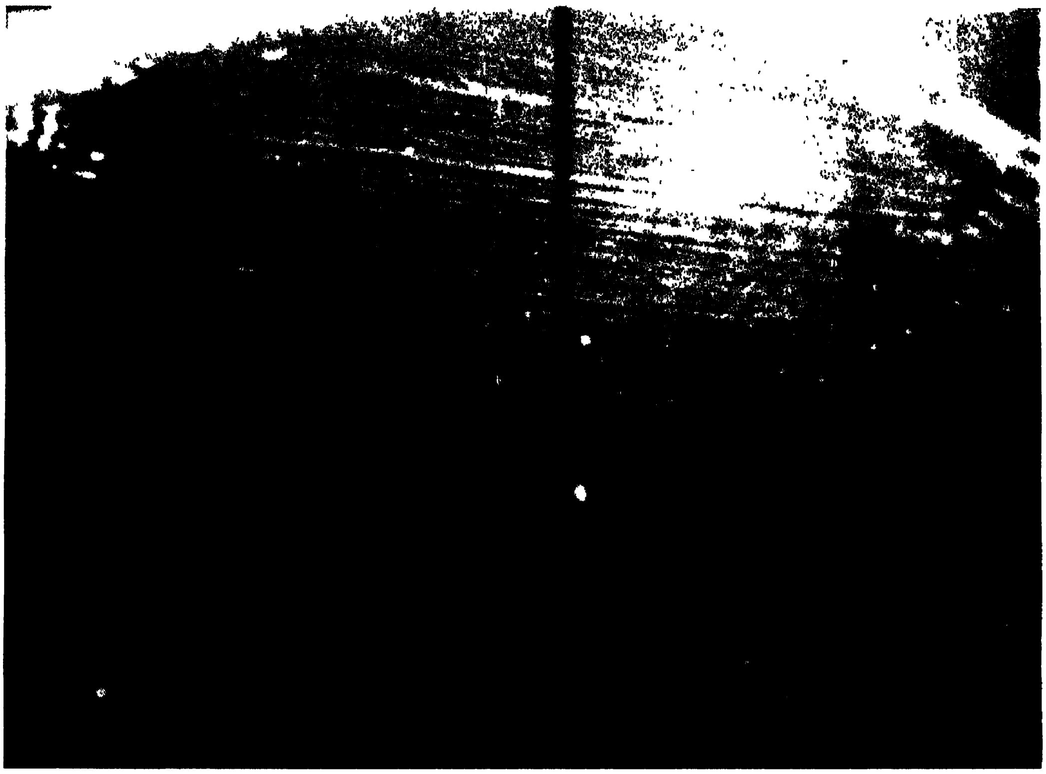

Fig 2

Single slit—6.2×0.17 cms. Temperature = 110°C. Substance paraffin.

More than two systems of overlapping fringes are distinctly seen. The finest fringe system is due to C H stretching vibrations.

$\lambda = 0.0036$ mms., Wave number = 2756 cm.$^{-1}$

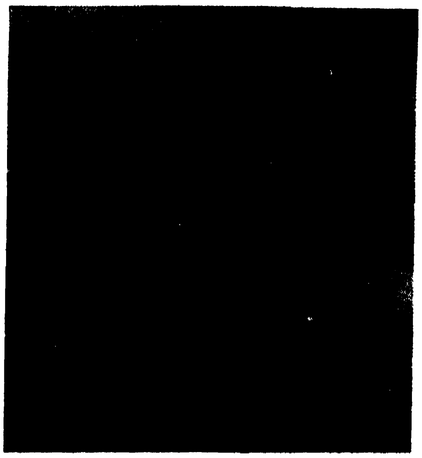

Fig 3

Single slit -6.2×0.17 cms Temperature $74°C$. Substance - sulphur

λ 0.01411 mms Wave number = 71 cm^{-1}

Since the fringe width of the fringe system increases with the rise of temperature, no definite conclusion regarding the interpretation of the associated radiation has yet been arrived at.

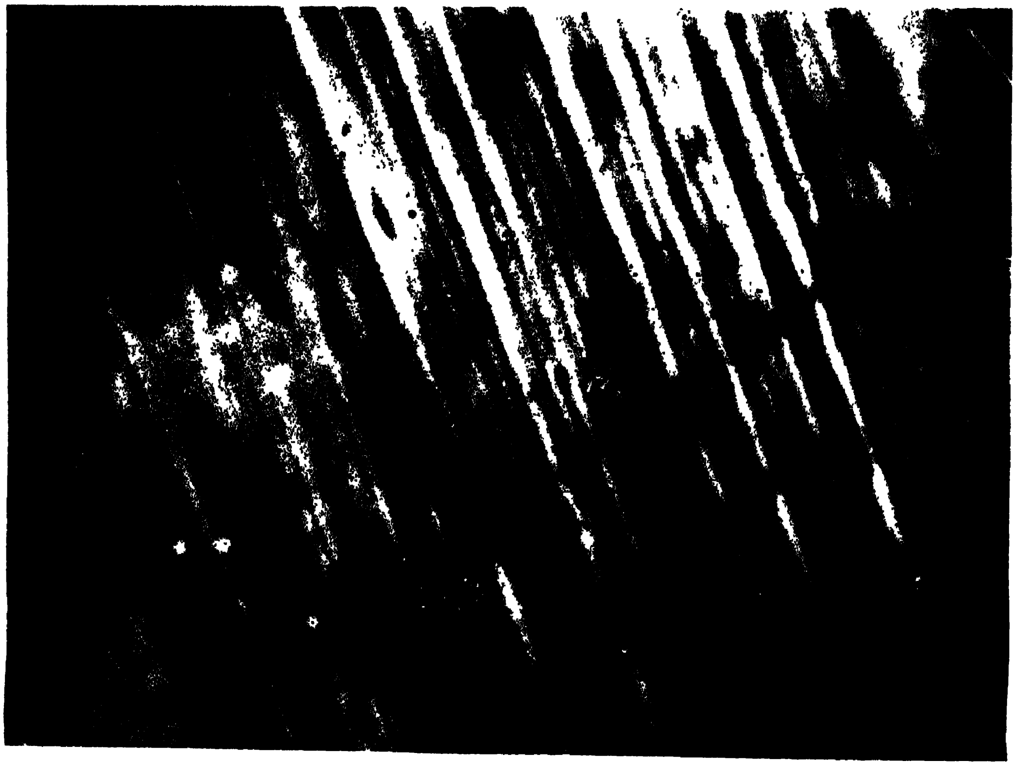

Fig. 4.

Single slit ;—6.2 × 0.17 cms. Temperature = 120°C Substance – sulphur.

From the picture it is distinct that the fringe system at places is crossed by still finer fringe systems. They are due to the overtones of the fundamental vibration of the S_2 molecule.

$\lambda_1 = 0.0081$ mms. $\lambda_2 = 0.004$ mms. $\lambda_3 = 0.0022$ mms. denote the wavelengths of the associated radiations due to the vibrations of the S_2 molecule.

TABLE I

Substance	Slit-width	Temperature in degree centigrade	λ from single slit eqn.	Theoretical average wave-length from eqn. $\lambda_{av} = \frac{2hcN}{3RT}$	Wave number in cm^{-1}	Raman's wave number in cm^{-1}	Interpretation
Paraffin	1.7 mms	74°C	0.2957 mm 0 0941 mm 0.0081 mm	0.0275 mm	33.8 166.3 1240.1	900 (Herzberg, 1945)	Rotational oscillation of a part of the molecule about the other part. —C—C—vibration.
Paraffin	Do	110°C	0.1747 mm 0.0403 mm 0.0037 mm	0.0254 mm	57 248 2756	3019 (Herzberg, 1945)	Rotational oscillation of a part of the molecule about the other fundamental C—H stretching vibration.
Sulphur	Do	74°C	0.1411 mm 0. 047 mm 0.0081 mm 0. 004 mm	0.0275 mm	71 213 1240 2481	58 216 (Venkateswaran, 1937)	Vibrational wave numbers of S_2 molecule
Sulphur	Do	120°C	0. 109 mm 0.0202 mm 0.0081 mm 0. 004 mm 0.0022 mm	0.0244 mm	92.6 496 1240 2481 4651	85 170 (Venkateswaran, 1937, 1935)	Vibrational wave numbers of S_2 molecule (fundamental and overtones).

the neighbourhood of those Raman lines observed in the case of crystals of sulphur. It is difficult at this stage to visualise how these vibrations give us the diffraction fringe system, as observed in the present case; the investigation with different slitwidths and other substances at different temperatures are in progress in order to verify that this is actually case of diffraction.

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